

Monthly report

Railway Field Laboratory

December 2022

Client: Swiss confederation; Federal Offices for the Environment (FOEN) and Transport (FOT), CH-3003 Bern
The FOEN and the FOT are offices of the Federal Department of the Environment, Transport, Energy and Communications (DETEC).

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Version: V1

Date: 15.2.2023

1. Status railway field laboratory

Construction work on the tracks:

- none

Downtimes of the measurement systems:

- Station MQ 1_1 from 25.12.2022 to 17.1.2023
- Station MQ 1_2 from 25.12.2022 to 17.1.2023
- Station MQ 1_3 from 12.11.2022 to 17.1.2023
- Station MQ 2_1 from 29.12.2022 to 17.1.2023
- Station MQ 2_2 from 25.12.2022 to 17.1.2023
- Station MQ 2_3 from 29.12.2022 to 17.1.2023

Downtimes of the sensors:

- none

Maintenance and sensor exchange:

- none

Modifications to the data, database, or analysis:

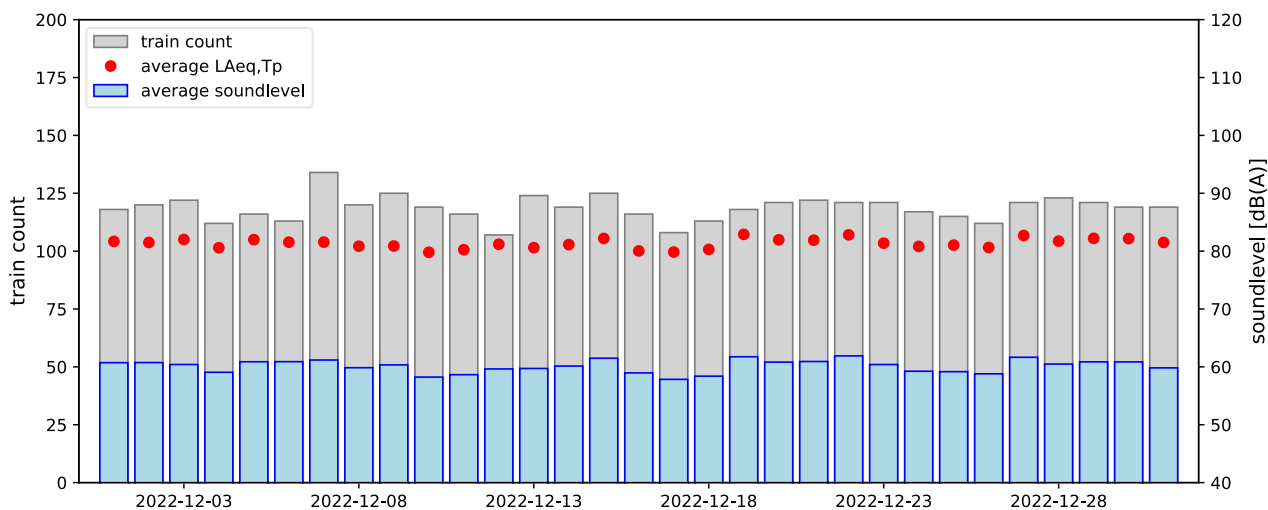
- none

Monthly data volume collected:

- 211 GB

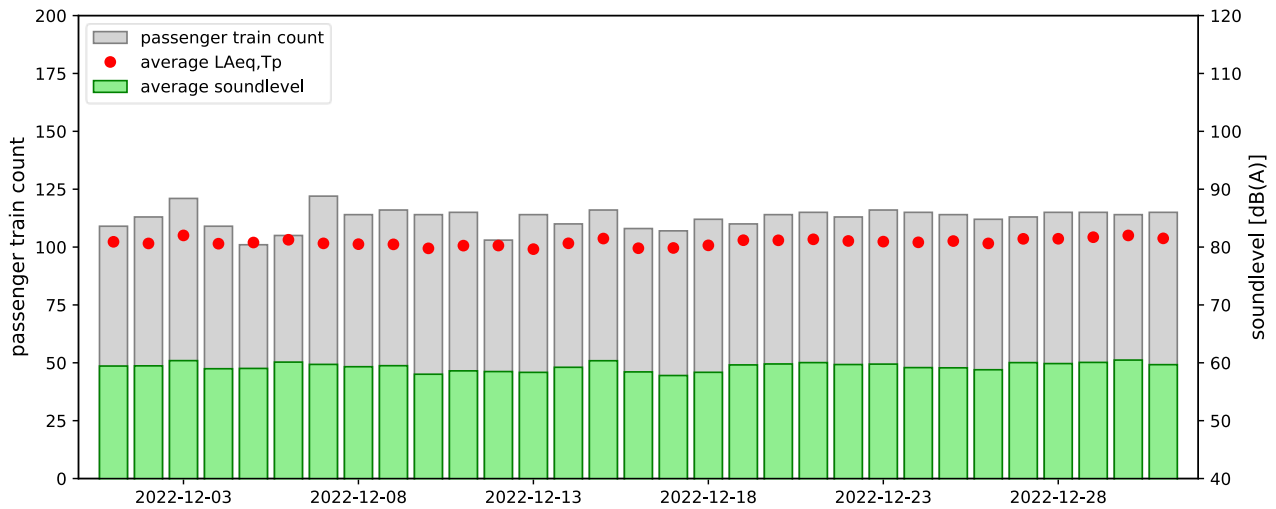
2. Measurement data

Daytime averages (24h) for all train passages at reference section (REF)



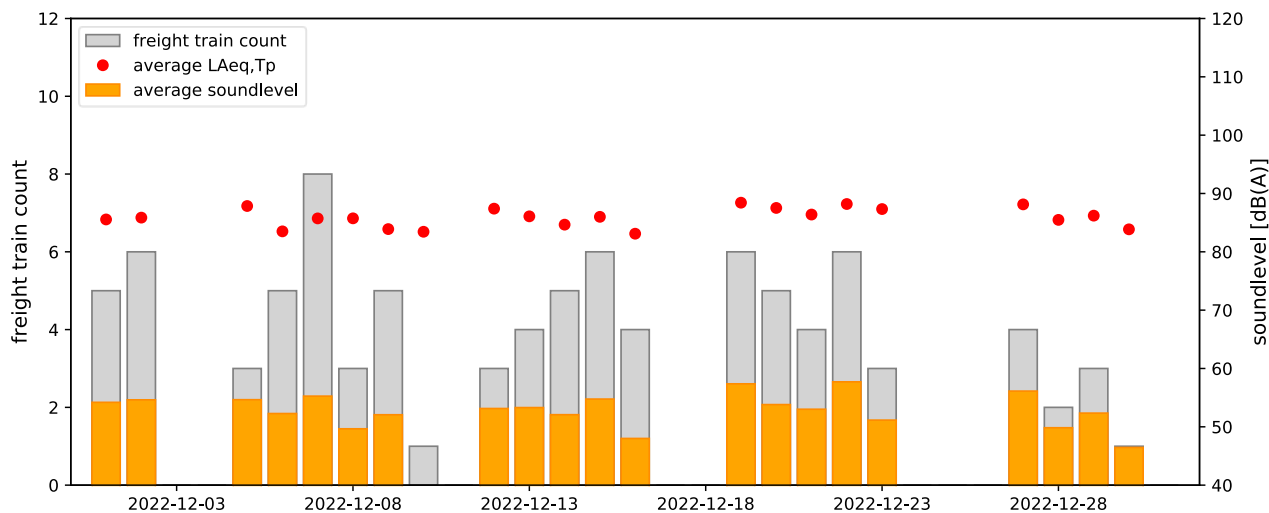
| date | location | train count | passenger train count | freight train count | service train count | average LAeqTp | average soundlevel |
|--------------|------------|-------------|-----------------------|---------------------|---------------------|----------------|--------------------|
| 01.12.2022 | REF | 118 | 109 | 6 | 0 | 81.7 | 60.7 |
| 02.12.2022 | REF | 120 | 113 | 6 | 0 | 81.5 | 60.7 |
| 03.12.2022 | REF | 122 | 121 | 0 | 0 | 82.0 | 60.4 |
| 04.12.2022 | REF | 112 | 109 | 0 | 2 | 80.6 | 59.1 |
| 05.12.2022 | REF | 116 | 101 | 4 | 3 | 82.0 | 60.9 |
| 06.12.2022 | REF | 113 | 106 | 5 | 0 | 81.6 | 60.9 |
| 07.12.2022 | REF | 134 | 122 | 8 | 0 | 81.6 | 61.2 |
| 08.12.2022 | REF | 120 | 114 | 3 | 1 | 80.8 | 59.9 |
| 09.12.2022 | REF | 125 | 116 | 5 | 1 | 80.9 | 60.3 |
| 10.12.2022 | REF | 119 | 114 | 1 | 0 | 79.8 | 58.2 |
| 11.12.2022 | REF | 116 | 115 | 0 | 0 | 80.2 | 58.6 |
| 12.12.2022 | REF | 107 | 103 | 3 | 0 | 81.2 | 59.6 |
| 13.12.2022 | REF | 124 | 115 | 4 | 1 | 80.6 | 59.7 |
| 14.12.2022 | REF | 119 | 110 | 5 | 0 | 81.1 | 60.1 |
| 15.12.2022 | REF | 125 | 116 | 6 | 1 | 82.2 | 61.5 |
| 16.12.2022 | REF | 116 | 108 | 4 | 1 | 80.0 | 59.0 |
| 17.12.2022 | REF | 108 | 107 | 0 | 0 | 79.8 | 57.8 |
| 18.12.2022 | REF | 113 | 112 | 0 | 0 | 80.3 | 58.4 |
| 19.12.2022 | REF | 118 | 110 | 6 | 1 | 82.9 | 61.7 |
| 20.12.2022 | REF | 121 | 114 | 5 | 1 | 82.0 | 60.8 |
| 21.12.2022 | REF | 122 | 115 | 4 | 0 | 81.9 | 60.9 |
| 22.12.2022 | REF | 121 | 113 | 6 | 0 | 82.8 | 61.9 |
| 23.12.2022 | REF | 121 | 116 | 3 | 0 | 81.4 | 60.4 |
| 24.12.2022 | REF | 117 | 115 | 0 | 0 | 80.8 | 59.2 |
| 25.12.2022 | REF | 115 | 114 | 0 | 0 | 81.0 | 59.2 |
| 26.12.2022 | REF | 112 | 112 | 0 | 0 | 80.6 | 58.8 |
| 27.12.2022 | REF | 121 | 113 | 4 | 0 | 82.7 | 61.7 |
| 28.12.2022 | REF | 123 | 115 | 2 | 1 | 81.7 | 60.5 |
| 29.12.2022 | REF | 121 | 115 | 3 | 1 | 82.2 | 60.9 |
| 30.12.2022 | REF | 119 | 114 | 1 | 1 | 82.2 | 60.9 |
| 31.12.2022 | REF | 119 | 115 | 0 | 0 | 81.5 | 59.8 |
| month | REF | 3677 | 3492 | 94 | 15 | 81.5 | 60.3 |

Daytime averages (24h) for all passenger train passages at reference section (REF)



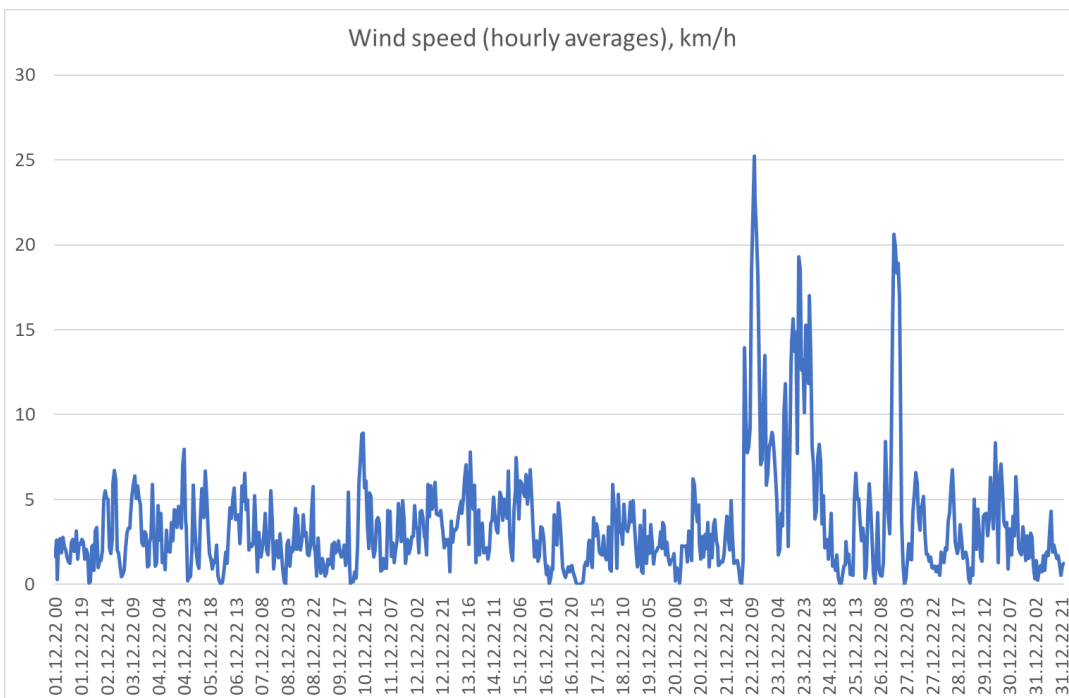
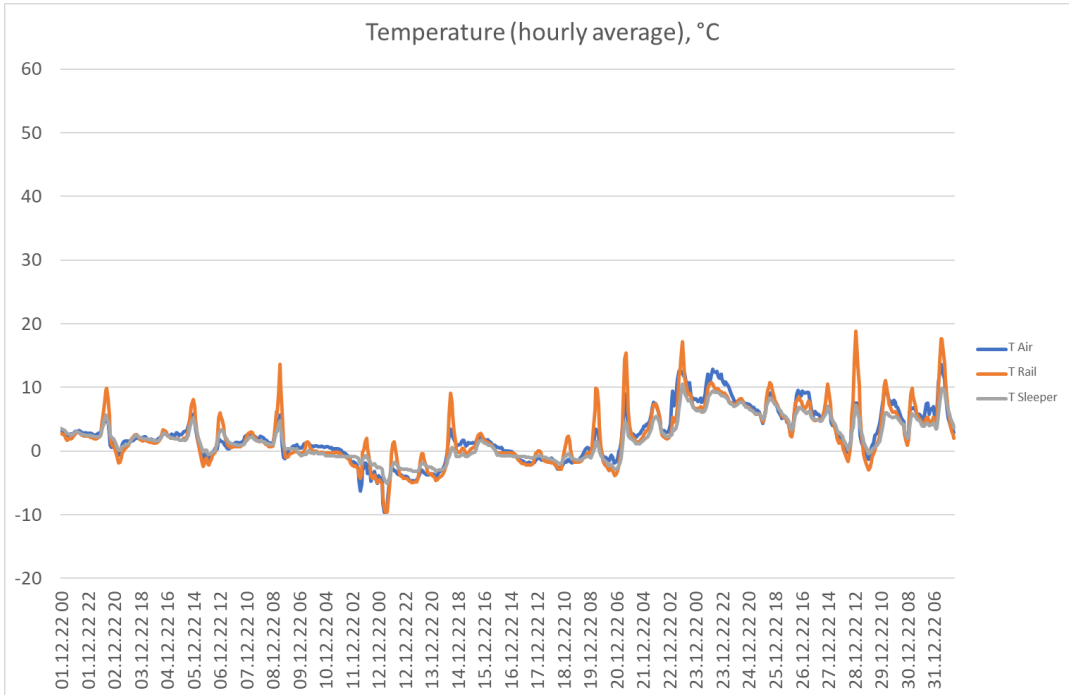
| date | location | passenger train count | average speed | average length | average axlecount | average LAeqTp | average soundlevel |
|--------------|------------|-----------------------|---------------|----------------|-------------------|----------------|--------------------|
| 01.12.2022 | REF | 109 | 111 | 159 | 23 | 80.9 | 59.4 |
| 02.12.2022 | REF | 113 | 112 | 164 | 24 | 80.6 | 59.5 |
| 03.12.2022 | REF | 121 | 110 | 137 | 20 | 82.0 | 60.4 |
| 04.12.2022 | REF | 109 | 110 | 151 | 22 | 80.6 | 59.0 |
| 05.12.2022 | REF | 101 | 112 | 160 | 23 | 80.8 | 59.0 |
| 06.12.2022 | REF | 106 | 111 | 162 | 24 | 81.3 | 60.1 |
| 07.12.2022 | REF | 122 | 111 | 158 | 23 | 80.6 | 59.7 |
| 08.12.2022 | REF | 114 | 111 | 160 | 24 | 80.5 | 59.3 |
| 09.12.2022 | REF | 116 | 111 | 163 | 24 | 80.5 | 59.5 |
| 10.12.2022 | REF | 114 | 112 | 140 | 21 | 79.8 | 58.0 |
| 11.12.2022 | REF | 115 | 109 | 141 | 21 | 80.2 | 58.6 |
| 12.12.2022 | REF | 103 | 110 | 156 | 23 | 80.3 | 58.5 |
| 13.12.2022 | REF | 115 | 111 | 157 | 23 | 79.6 | 58.3 |
| 14.12.2022 | REF | 110 | 111 | 157 | 23 | 80.6 | 59.2 |
| 15.12.2022 | REF | 116 | 111 | 157 | 23 | 81.5 | 60.4 |
| 16.12.2022 | REF | 108 | 112 | 164 | 24 | 79.8 | 58.4 |
| 17.12.2022 | REF | 107 | 111 | 137 | 20 | 79.8 | 57.8 |
| 18.12.2022 | REF | 112 | 110 | 135 | 20 | 80.3 | 58.4 |
| 19.12.2022 | REF | 110 | 112 | 156 | 23 | 81.2 | 59.6 |
| 20.12.2022 | REF | 114 | 111 | 154 | 23 | 81.2 | 59.8 |
| 21.12.2022 | REF | 115 | 111 | 157 | 23 | 81.3 | 60.0 |
| 22.12.2022 | REF | 113 | 112 | 158 | 23 | 81.1 | 59.7 |
| 23.12.2022 | REF | 116 | 112 | 163 | 24 | 80.9 | 59.8 |
| 24.12.2022 | REF | 115 | 111 | 140 | 21 | 80.8 | 59.2 |
| 25.12.2022 | REF | 114 | 110 | 130 | 19 | 81.0 | 59.1 |
| 26.12.2022 | REF | 112 | 108 | 134 | 20 | 80.6 | 58.8 |
| 27.12.2022 | REF | 113 | 111 | 146 | 21 | 81.4 | 60.0 |
| 28.12.2022 | REF | 115 | 112 | 147 | 22 | 81.4 | 59.9 |
| 29.12.2022 | REF | 115 | 112 | 146 | 21 | 81.7 | 60.1 |
| 30.12.2022 | REF | 114 | 112 | 154 | 23 | 82.0 | 60.5 |
| 31.12.2022 | REF | 115 | 111 | 140 | 21 | 81.5 | 59.7 |
| month | REF | 3492 | 111.1 | 151.0 | 22.3 | 80.9 | 59.4 |

Daytime averages (24h) for all freight train passages at reference section (REF)



| date | location | freight train count | average speed | average length | average axle count | average LAeqTp | average soundlevel |
|--------------|------------|---------------------|---------------|----------------|--------------------|----------------|--------------------|
| 01.12.2022 | REF | 6 | 82 | 267 | 66 | 85.5 | 54.2 |
| 02.12.2022 | REF | 6 | 89 | 251 | 60 | 85.9 | 54.6 |
| 03.12.2022 | REF | 0 | | | | | |
| 04.12.2022 | REF | 0 | | | | | |
| 05.12.2022 | REF | 4 | 84 | 319 | 79 | 87.9 | 54.6 |
| 06.12.2022 | REF | 5 | 83 | 250 | 59 | 83.5 | 52.3 |
| 07.12.2022 | REF | 8 | 86 | 205 | 45 | 85.7 | 55.3 |
| 08.12.2022 | REF | 3 | 85 | 175 | 32 | 85.7 | 49.7 |
| 09.12.2022 | REF | 5 | 74 | 209 | 48 | 83.9 | 52.1 |
| 10.12.2022 | REF | 1 | 76 | 65 | 16 | 83.4 | 39.2 |
| 11.12.2022 | REF | 0 | | | | | |
| 12.12.2022 | REF | 3 | 78 | 227 | 45 | 87.4 | 53.1 |
| 13.12.2022 | REF | 4 | 90 | 274 | 56 | 86.1 | 53.3 |
| 14.12.2022 | REF | 5 | 85 | 210 | 38 | 84.7 | 52.1 |
| 15.12.2022 | REF | 6 | 83 | 229 | 57 | 86.0 | 54.8 |
| 16.12.2022 | REF | 4 | 93 | 162 | 36 | 83.1 | 48.0 |
| 17.12.2022 | REF | 0 | | | | | |
| 18.12.2022 | REF | 0 | | | | | |
| 19.12.2022 | REF | 6 | 83 | 251 | 60 | 88.4 | 57.4 |
| 20.12.2022 | REF | 5 | 77 | 154 | 34 | 87.5 | 53.8 |
| 21.12.2022 | REF | 4 | 89 | 235 | 52 | 86.4 | 53.0 |
| 22.12.2022 | REF | 6 | 81 | 275 | 66 | 88.2 | 57.7 |
| 23.12.2022 | REF | 3 | 93 | 173 | 40 | 87.3 | 51.1 |
| 24.12.2022 | REF | 0 | | | | | |
| 25.12.2022 | REF | 0 | | | | | |
| 26.12.2022 | REF | 0 | | | | | |
| 27.12.2022 | REF | 4 | 88 | 319 | 72 | 88.1 | 56.1 |
| 28.12.2022 | REF | 2 | 92 | 289 | 58 | 85.5 | 49.8 |
| 29.12.2022 | REF | 3 | 96 | 309 | 67 | 86.2 | 52.3 |
| 30.12.2022 | REF | 1 | 87 | 350 | 84 | 83.9 | 46.5 |
| 31.12.2022 | REF | 0 | | | | | |
| month | REF | 94 | 85.0 | 235.8 | 53.2 | 86.4 | 52.1 |

3. Weather data



Appendix: measurement quantities

Transit Exposure Level *TEL*

A-weighted sound pressure level of a single train pass-by as energetic average over the entire exposure duration T and averaged over the pass-by duration T_p .

$$TEL = 10 \log \left(\frac{1}{T_p} \int_0^T \frac{p_A^2(t)}{p_0^2} dt \right) \quad (1)$$

Where

$p_A(t)$ = the A-weighted sound pressure, [Pa]

$p_0 = 20 \mu Pa$ (reference pressure), [Pa]

$T_p = T_2 - T_1$ = pass-by duration of the train, time interval during which a train is within the measurement cross-section and which starts with the entry time T_1 into the measurement cross-section and ends with the exit time T_2 , [s]

T = time interval which starts when the smoothed sound pressure level (sound pressure level smoothed as a function of time with the frequency weighting A and a time weighting F („fast“) or averaging over a duration period of time, e.g. 100 ms) is for the last time 10 dB below that prevailing at the time of entering the measurement cross-section and which ends when the smoothed sound pressure level is for the first time 10 dB below the one at the time of leaving the measurement cross-section. [s]

A-weighted equivalent sound pressure level of the train pass-by $L_{Aeq,Tp}$

The A-weighted equivalent sound pressure level equals the (energetic) average of the sound pressure level over the train pass-by time T_p according to the following equation:

$$L_{Aeq,Tp} = 10 \log \left(\frac{1}{T_p} \int_{T_1}^{T_2} \frac{p_A^2(t)}{p_0^2} dt \right) \quad (2)$$

where

$p_A(t)$ = the A-weighted sound pressure, [Pa]

$p_0 = 20 \mu Pa$ (reference sound pressure), [Pa]

$T_p = T_2 - T_1$ = pass-by duration of the train, [s]

Sound Exposure Level *SEL*

The sound exposure level *SEL* references the acoustic energy of the entire pass-by event to one second. The SEL is used in calculating average sound level contributions from trains over longer periods of time (i.e. days/months/year). The SEL is related to the transit exposure level TEL through:

$$SEL = TEL - 10 \log (T_0 / T_p) \quad (3)$$

where

$T_0 = 1$ [s]

T_p = pass-by duration of the train, [s]

Average sound level (period)

Average (energetic) A-weighted sound pressure level measured over a given period of time.

For the average sound level contributions from train pass-byes this equals the sum (energetic) of all sound exposure levels during the period for a given measurement position:

$$\text{average soundlevel} = 10 \cdot \log_{10} \left(\sum 10^{\frac{SEL}{10}} \right) - A1 \quad (4)$$

where

$A1 = 10 \cdot \log_{10}(n \cdot 24 \cdot 3600)$ for a 24-hour period

SEL (see equation 3) taken from measurement data

n = number of days being averaged over

Average $L_{Aeq,Tp}$

Average (energetic) sound level of all the A-weighted sound pressure levels from the individual equivalent sound level of all train pass-byes in a given period of time (day/month/year).

Calculated per train category and per period day/night, month, year, etc. and per measurement location:

$$\text{average } L_{Aeq,Tp} = 10 \cdot \log_{10} \left(\sum T_p \cdot 10^{\frac{L_{Aeq,Tp}}{10}} \right) + 10 \cdot \log_{10} \left(\frac{1}{\sum T_p} \right) \quad (5)$$

where

T_p = pass-by duration of the train [s]

$L_{Aeq,Tp}$ (see equation 2) is calculated directly from the measurement data